

Index

- ablation, *see melting*
 absolute instability, 160, 167, 197, 203, 212
 frequency, 182, 183, 190, 195, 198, 205, 223
 growth rate, 182, 190, 200, 210
 in solidification, 419
 in viscous fingering, 83
 nonlinear development, 212, 218
 saddle-point condition, 180
 adiabatic cooling, 586
 advection-diffusion, 350, 402, 413, 426, 497
 Airy's equation, 145
 alpha-effect, 369, 373, 375, 378
 alpha-omega dynamo, 378
 Alfvén
 theorem, 351
 velocity, 355
 waves, 354, 377
 group velocity, 355
 Antarctic plateau, 558
 Antarctica, 514
 anti-frictional behaviour, 563, 613
 anticyclones, 603
 arteries 105, 107
 atherogenesis, 107, 137
 atherosclerosis, 105
 wall shear stress, 137
 atmospheric pollution, *see pollution*
 Austausch length, 563
 available potential energy, 292, 597

 backward diffusion, 18
 bacterial colonies, pattern formation in, 68
 ballerina effect, 584
 baroclinic
 fluid, 293
 generation of vorticity, 292, 293
 instability, 538, 581, 620
 barotropic
 fluid, 293
 instability, 581
 basalt, 448, 458, 461, 464, 466, 470, 472
 Beavers-Joseph condition, 428
 Beltrami field, 375, 381, 387

 Bénard convection, *see Rayleigh-Bénard convection*
 beta plane, 605
 bifurcations of tubes, 137
 binary alloys, 407
 Biot number, 19
 black smokers, 320, 496
 blood flow, 105
 blood-pressure cuffs, 119
 bolus transport, 569
 Bond number, 14
 bora winds, 574
 boundary layers
 compositional, 415, 417, 418
 in the ocean, 509, 551
 magnetic, 361, 363
 on a rotating disk, 189, 210
 impulse response, 195
 steady streaming, 567
 thermal, 403, 455, 469
 boundary mixing, 544
 Boussinesq approximation, 291, 295, 322
 Boussinesq equation, 294
 Brazil Basin, 511, 528, 533
 Brewer-Dobson circulation, 614
 Briggs-Bers criterion, 182, 189, 191, 195, 211, 224
 brine channels, *see chimneys in mushy layers*
 Brunt-Väisälä (buoyancy) frequency, 308, 313, 535, 541, 574, 586

 cabbelling, 550
 capillary
 effects, 62, *see also Marangoni, thermocapillarity*
 length, 64, 401, 414, 415
 number, 12, 39
 carbon 14, 529
 Casimir invariants, 585, 606, 608, *see also isovorticity*
 causality, 175, 178, 184, 188
 chaos, 233
 order out of, 562
 chaotic wandering, 381
 chimneys

in mushy layers, 436, 439
 in the ocean, 514
 chinook winds, 574
 chlorofluorocarbons (CFCs), *see pollution*
 choked flows, 128, 132
 climate change, 507
 human influence on, 560
 closure problem, 281, 370
 coherent structures, 253, 264
 collapsible tubes, 119
 experiments, 120, 134
 flow instability in, 135
 Hopf bifurcation, 136
 flow limitation, 120, 121, 132
 flow of urine, 120
 flow separation in, 134
 pressure-drop limitation, 121
 steady flow in, 127
 viscous collapse, 128
 compaction, 458, 501
 experiments, 502
 group velocity, 502
 condensation, 23, 41
 conduction of heat, 452, 469
 similarity solution, 453
 constitutional supercooling, 411
 contact angle, 36, 42
 hysteresis, 39
 contact line, 31, 43
 intermediate angle, 36
 moving, 33, 47, 48
 singularity, 3, 34
 continuity equation, *see mass-conservation equation*
 convection, 289, 376, 462, 500, *see also Rayleigh-Bénard convection, double-diffusive convection*
 at high Rayleigh numbers, 300, 332, 406, 455, 461
 compositional, 417, 451, 456, 459
 deep oceanic, 513, 515
 during solidification, 417
 experiments, 455
 helical, 379
 in a mushy layer, 429
 in a porous medium, 434
 convective instability, 160, 167, 212
 in solidification, 419
 in viscous fingering, 83
 nonlinear development, 212
 convective overturning, 572
 core of the Earth, 449, 500
 Coriolis
 effects, 564
 force, 338, 348, 376
 parameter, 337, 592
 stiffness, 591
 waves, 589
 COSPAR international reference atmosphere, 560
 counter-gradient flux
 of heat, 317

 of momentum, 247, 563
 Cowling's theorem, 369, 379
 Cox number, 534
 cracks, growth of, 69, 471
 critical layer, 573, 574, 597, 599, 606, 608
 crystallization, 454, 456-459, 464-466, 476, *see also solidification*
 cumulonimbus convection, 588
 current sheets, 388
 curved fronts, propagation of, 69
 curved tubes, secondary flow in, 106, 138
 cyclones, 603

 Darcy's law, 423, 495, 502
 Darcy number, 425
 decompression, 476, 477
 delayed oscillator, 518
 dendritic crystal, 68, 77, 92, 420
 diapycnal
 diffusivity, 529, 537
 mixing, 525, 532, 553
 diffusion equation, 395, 409
 diffusion-limited aggregation (DLA), 65, 85, 88, 91
 rate of occupancy, 87
 diffusivity ratio (Lewis number), 325, 410, 430, 535, 547
 direct numerical simulation (DNS), 276
 directional growth
 in solidification, 94, 98, 413
 in viscous fingering, 58, 93
 dissipation of energy
 in turbulent flow, 244, 248, 250, 267, 280, 535
 on subgrid scales, 249, 279
 viscous, 236, 279
 distribution coefficient, 409
 dividing surface, *see interface*
 Doppler shift, 572, 577, 596
 double-diffusive convection, 321, 431, 456, 546
 buoyancy ratio, 431, 547
 diffusive mode, 323, 329
 diffusive interface, 331, 334, 335
 finger interface, 330, 332
 intrusions, 550
 layers and staircases, 330, 334, 457, 458
 salt fingers, 323, 327, 328,
 drag, on a circular cylinder, 283
 dykes, 466-477, 501
 similarity solution, 473
 dynamo, *see also alpha effect, alpha-omega dynamo*
 action, 367, 375, 376
 cycle, 379
 fast, 368
 instability, 348, 351, 367
 slow, 368
 theory, 367
 first-order smoothing, 372

 Earth, its formation, 448
 Eddington-Sweet circulation, 338
 eddies, in the ocean, 538
 eddy

- diffusivity, 371, 516
- flux, 527
- parameterization, 513
- transport barrier, 612, 617
- viscosity, 247, 249, 257, 265, 267, 278, 280
- Ekman layer flux, 552
- El Niño (ENSO), 518, 615
- elastic tubes
 - characteristic admittance of, 113
 - constriction, 130
 - jumps, 116, 133
 - tube law, 110
 - waves
 - in characteristic curves, 115
 - long-wave approximation, 110, 116
 - speed index, 128
 - speed of, 110
- electromagnetic shaping and stirring, 356
 - pinch effect, 356
- electromotive force, 370
- Eliassen-Palm
 - effect, 598, 605
 - flux, 568
- energy
 - cascade, 233
 - dissipative range, 236, 239, 268, 276, 277
 - inertial range, 236, 243, 251, 268, 277
 - structure function,
 - dissipation, *see dissipation of energy*
 - inverse cascade, 280
 - premultiplied spectrum, 243, 281
 - production, 248, 267
 - spectrum, 241
 - three-dimensional spectrum, 245
 - transfer rate, 235, 277
- enthalpy, 290, 411
- entrainment, 460, 478, 484, 488, 490, 496
 - assumption, 307, 310, 314
 - constant, 306, 308, 310, 312
 - parameter, 337
- Ertel's theorem, 584
- Eulerian mean equations, 568
- Eulerian mean velocity, 569
- eutectic point, 408
- evaporation, 23, 41
 - one-sided model, 25
- exchange of stabilities, 298, 328
- expiration, forced, 120
- extrinsic dynamics, *see noise amplifiers*

- f-plane, *see flat-Earth approximation*
- Faraday's law of induction, 349
- filling box, 315, 457
- film flows, *see thin films*
- fissures, *see dykes*
- flat-Earth approximation, 337, 593
- flow oscillators, intrinsic dynamics, 159, 161, 166, 189
- flow separation, 137
- flux ratio, 331, 333, 334, 335
- flux tube, 385

- form drag, 569
- fountain, 459
- fractals, 252
 - dimension, 84
 - growth, 86, 90, 92
- freezing-point depression, *see Gibbs-Thomson effect, liquidus*
- friction velocity, 266
- front dynamics, 212, 223
- frozen-field equation in MHD, 351
- frozen-temperature approximation, 413

- gas dynamics, 474, 477
- geostrophy, 338, 512, 530, 590
- geothermal reservoirs, 498
- Gibbs-Thomson effect, 67, 399, 400, 413
- Ginzburg-Landau equation, 173, 182, 198, 206, 213, 224
- global instability, 193, 197, 212
 - frequency selection, 204, 211, 220
- global modes, 160, 166, 183, 191, 194, 203
 - nonlinear modes, 218, 224
 - healing length, 219
- granite, 448, 461, 472
- gravity currents, 335, 484, *see also spreading of viscous liquids*
 - box models, 484, 487, 489
 - similarity solution, 487
 - viscous, 492
 - similarity solution, 493
- gravity waves, *see internal gravity waves*
- greenhouse gases, 557, 588
- group velocity, 181, 204
- Gulf Stream, 507, 522, 538, 587
- gyroscopic pumping, 564, 610, 618, 620

- hairpin vortices, 139, 272
- Hamaker constant, 16
- heat conservation, 426
- Hele-Shaw cell, 58
- helical convection, 379
- helicity, 348
 - magnetic, 352, 384
 - spectrum function, 374
- horseshoe vortices, *see hairpin vortices*
- hotel shower, 520
- hydraulic jump, 510
- hydrostatic relation, 291, 562
- hydrothermal circulation, 495

- ideal gas law, 465, 561
- impulse response, 172, 195, 213
- indented channels, 140
 - boundary-layer scaling, 143
 - core-flow displacement, 144
 - cross-stream pressure gradient, 142, 143
- induction, *see Faraday's law*
- inductive stirring, 361
- inertia-gravity waves, 599
 - dispersion relation for, 593
- inertial waves, 338, 374, 512, 589

- instability, *see also absolute, convective, global, local, spatial, temporal*
 control, 416
 linear, 170, 175, 181
 of a heated fluid layer, 294
 of a fluid interface in a porous medium, 60
 of magnetic flux tubes, 385
 of shear flows, 159
 of solidification fronts, 399
 of superposed fluids, 14
 of surface-tension-driven flows, 22
 integral length, 235
 interfaces, 1, 56, 399
 mush–liquid, 426
 interfacial
 corners and cusps, 45
 force, constitutive equation, 7
 jump conditions, 5
 region, 4, 427
 singularity, 42
 temperature, constitutive equation, 24
 tension, *see surface tension*
 intermittency, 249, 306
 internal (gravity) waves, 321, 535, 537, 540, 565
 dispersion relation, 54, 594
 group velocity, 541
 internal reflection, 541
 internal tide, 544
 intrinsic dynamics, *see flow oscillators*
 intrusion
 magmatic, 474
 oceanic, 549
 of eruption column, 477, 482, 492
 isomagnetic
 foliation, 383
 subspace 382
 isopycnals, 523, 583
 lateral dispersion on, 525, 532
 isotropic turbulence, 239, 371
 isovorticity, 383, *see also Casimir invariants*
- Karman constant, 267
 Karman vortex street, 159, 167, 192, 211
 katabatic flows, 335
 KdV equation, 149
 Kelvin's circulation theorem, 351, 566
 Kelvin–Helmholtz instability, 260, *see also shear flow instability*
 cat's eyes, 608
 nonlinear development, 261
 sheared-disturbance structure, 599
 vortices, 161, 162
- knots, 384
 ideal, 386
- Kolmogorov
 constant, 243
 four-fifths law, 240
 scale, 237, 244, 267, 561
- Korotkov sounds, 123
- Lagrangian
 integral time scale, 524
 mean velocities, 569
 point of view, 380
 Landau equation, 165
 Langmuir circulation, 551
 Laplace condition, 7, 11
 large-eddy simulation (LES), 277, 551
 latent heat
 of solidification, 67, 394, 430, 461, 470
 of vaporization, 24, 42
 lava, 393, 447, *see also magma*
 domes, 484, 494
 lakes, 440
 Lewis number *see diffusivity ratio*
 Lighthill radiation, 590
 liquid-metal magnetohydrodynamics, 347, 351
 liquidus, 408, 420
 local instability, 190, 199, 200, 212
 logarithmic velocity profile, 267, 273
 Lorentz force, 347, 354, 356, 361, 379
 back reaction, 376, 379
 lubrication theory, 8, 59, 492
 Reynolds equation, 9, 13
- magma, 447, 478, *see also lava*
 chambers, 452, 495
 experiments, 457, 459, 466
 transport through the crust, 466, 501, *see also dykes*
 elastic effects, 471
- magnetic
 diffusivity, 350
 flux linkage, 352
 flux tube, 384
 instability of, 385
 helicity, 352, 384
 interaction parameter, 377
 levitation, 365
 relaxation, 381, 384, 387
 topological constraint, 380
 resistivity, 355
 Reynolds number, 350, 372
- magnetic field
 force-free, 381
 generation, 378, *see also dynamo*
 rotating, 356
 spectrum of fluctuations 377
 topology, 353, 380
- magnetohydrodynamic approximation, 349
 magnetostatic equilibrium, 348, 379
- Marangoni
 effect, 8, *see also thermocapillarity*
 number, 21, 41
- mass-conservation equation, 10, 110, 294, 423, 471, 591
- Maxwell stress tensor, 354
 mean free path, 561
 mean-field theory
 electrodynamics, 369
 fractal aggregates 92
 Meddies, 550

- Mediterranean Sea, 510, 514
 salt tongue, 530
 melting, 460, 469
 mesoscale eddies, 534, 538
 Michaelson-Morley principle, 578
 middle atmosphere, 557
 mixing efficiency, 575
 mixing layers, 162, 189, 200
 mixing length, 524, 563
 Moens-Korteweg wave speed, 111
 morphological (morphogenetic) instability, 53, 66,
 93, 399, 412, 413
 with flow, 413
 group velocity, 419
 morphological number, 414, 428
 moving contact lines, 32, 47
 effective slip, 34
 Mullins-Sekerka instability, *see morphological
 instability*
 Murgatroyd-Singleton circulation, 614
 mushy layers, 394, 419, 456
- natural ventilation, 317
 neutral level, 318, 474
 noctilucent clouds, *see polar mesospheric clouds*
 noise amplifiers, extrinsic dynamics, 159, 161, 166,
 189
 non-acceleration constraint, 575
 normal modes, 168
 Nusselt number, 299
- ocean circulation, 509
 Ohm's law, 349
 Orr-Sommerfeld equation, 168, 192, 211
 oscillations
 delayed, 518
 overstability, 325, 339
 self-excited, 123
 Ozmidov scale, 536
 ozone
 destruction, 619
 hole, 558
 stratospheric, 557
- particle-driven flows, 488
 pattern formation, 53
 in a diffusive field, 57, 67
 in a Laplacian field, 54
 permeability, 423, 495, 502
 phase transformation, 23, 47, *see also
 condensation, evaporation, melting,
 solidification*
 stress balance during 24
 phase velocity, 168, 174, 419, 502, 569
 Phillips effect, 613
 planetary vorticity, 513
 plate tectonics, 451
 Plumb-McEwan experiment, 577, 596
 plumes, 303, 320, 342, 455, 479, 495
 forced, 312
 non-Boussinesq, 305, 309, 480
- polar mesospheric clouds, 558, 565
 polar vortex, 611
 pollution
 atmospheric 290, 320
 chlorofluorocarbons (CFCs), 529, 557, 616
 greenhouse gases, 557, 588
 marine, 525
 porous media, 59, 495, 502, *see also Darcy's law*
 reactive, 394, 423, 435, 497, *see also mushy
 layers*
 potential temperature, 582
 potential vorticity, 580
 inversion, 585, 599, 612
 scale effects in 602, 605
 isentropic gradients of, 603
 rearrangement, 608
 Prandtl number, 19, 296, 402
 Prandtl's ratio of scales, 602
 precursor film, 36, 39
 printer's instability, 95
 pseudo-scalar, 371, 373
 pseudomomentum, 569, 597, 606
 pulse propagation, 108
 nonlinear analysis, 115
 viscous effects, 116
 pyroclastic flows, 484, 490
- quasi-biennial oscillation (QBO), 558, 563, 578,
 615
 quasi-geostrophy, 615
- radiation stress, 568, 598
 radiative damping, 580
 Rayleigh-Bénard convection, 294, 374
 Rayleigh equation, 169, 189
 Rayleigh number, 293
 compositional, 325, 431
 critical values, 298, 326
 with rotation, 340
 mushy layer, 431
 porous medium, 431
 thermal, 296, 431, 455, 462
 Rayleigh-Taylor instability, 14
 reaction equation, 497
 reflectional symmetry, 374, 376
 refrigeration effect, 565, 586, 588, 590, 618
 relative dispersion, 532
 Reynolds decomposition, 521
 Reynolds number, 12, 106, 231, 459, 485
 Reynolds stress, 246, 535, 565, 598
 rhyolite, 448, 464, 466
 Richardson diffusion law, 245
 Richardson number, 548, 574
 Riemann invariants, 115
 Rossby
 height, 602
 number, 341, 374, 591
 radius, 602
 waves, 513, 581, 603, 605, 612, 615
- Saffman-Taylor fingers, 69

analytic solutions, 72
 anomalous fingers, 78
 sector-shaped channels, 74
 selection by surface tension, 72
 side-branching instability, 82, 83
 Saffman-Taylor instability, 60, 498
 salt fingers, *see double-diffusive convection*
 saturation temperature, 23
 Schmidt number, 418
 sea ice, 405, 436, 553
 sea water, equation of state, 550
 secondary flow, 138
 sedimentation, 488-492
 segregation coefficient, 409
 sensible heat, *see enthalpy*
 separation of scales, *see spectral gap*
 shallow water theory, 486, 489
 shear-flow instability, 159, 259, 541
 dispersion relation, 160, 167, 173, 195, 198, 221
 open flows, 161
 tanh profile, 170, 189
 shear layer, 255
 signalling problem, 170, 186, 200
 skew flux, 523, 538
 skin effect, 361
 slip, effective, 34, 363
 smelting, 360
 solar flares, 388
 solidification, 393, 450, *see also crystallization*
 instability, *see morphological instability*
 near a stagnation point, 401
 of a droplet, 47
 of dykes 467
 solubility of gas, 465
 solute conservation, 426
 spatial instability, 167, 173, 186, 200
 envelope, 198
 growth rate, 191
 spatio-temporal chaos and intermittency, 97
 spectral gap (separation of scales), 244, 522, 532
 spreading of viscous liquids, 37, 40, *see also gravity currents*
 with evaporation, 42
 stability, *see instability*
 stagnation-point flow, 401
 static stability, *see stratification, stable*
 Stefan
 condition, 394, 421
 number, 396, 410, 430, 470
 problem, 55, 395
 similarity solution, 396
 Stokes drift, 523, 570
 Stokes wave, 42
 Storm tracks, 615
 Strait of Gibraltar, 510
 stratification, 291
 in magma chambers, 457
 stable, 583, 586
 stratosphere, 558, 617
 streamwise streaks and vortices, 271
 Strouhal number, 141, 163

structure function, 237, 240, 251
 subcritical flow, 128
 subgrid
 processes, 508
 stress tensor, 278
 supercooling
 constitutional, 411, 415, 420
 due to curvature, *see Gibbs-Thomson effect*
 interfacial, 437
 kinetic, 398, 441
 supercritical flow, 128
 surf zone, 574
 surface energy, 399
 surface mixed layer, 529
 surface tension, 2, 7, 12, 37, 41, 48, 399
 gradient, 8, *see also thermocapillarity*
 symmetry breaking, 577
 Taylor identity, 610
 Taylor microscale, 239
 Taylor number, 339
 Taylor-Proudman theorem, 338
 temporal instability, 167
 growth rate, 174, 190
 thermal-wind relation, 590, 592, 618
 thermals, 303, 321
 thermobaricity, 550
 thermocapillarity, 18, 27, 40
 dryout, 21, 22
 thermocline, 517, 537
 thermodynamic equilibrium, 24, 408
 thermohaline circulation, 516, 517, 537
 thermohaline convection, *see double-diffusive convection*
 thin films
 evolution equation, 13, 17, 21, 27, 28, 40
 locally parallel flow, 9
 long-wave theory, 28
 rupture, 16, 43
 similarity solution, 44
 vertically falling, 28
 Thorpe scale, 536
 tip-splitting instability, 81
 trajectory splitting, 3, 43, 47
 tropopause, 583
 troposphere, 557
 turbidity currents, 484, 491
 turbulence, 231
 control, 264
 homogeneous, 371
 in free shear, 255
 mixing, 264, 527
 spectra
 correlation function, 242
 cospectra, 242, 246
 wall-bounded, 265
 turbulent
 convection, *see convection at high Rayleigh numbers*
 energy cascade, *see energy cascade*
 flows, 366, 460, 465, 467, 488

- twist, 385
- van der Waals forces, 16, 21, 27, 39
- vapour thrust, 23, 25, 27
- veins, 105, 119
 - giraffe jugular, 123, 134
- viscous dissipation, *see dissipation of energy*
- viscous fingering, 53
 - in miscible fluids, 64
- volatiles, 464, 467, 474, 478
- volcanic
 - eruptions, 313, 447, 464, 467, 501
 - eruption columns, 477, 490
- vortex stretching and tilting, 584
- vorticity conservation, 513
- vorticity equation, 591
- wakes, 161, 166, 189, 191, 200, 203, 212
- wall shear stress, 151
- wall units, 267
- wave,
 - action, 574, 598
 - breaking, 567, 570, 575
 - internal gravity waves, 572
 - ocean-beach analogy, 565, 574
 - Rossby waves 581
- energy, 569, 597
- filtering, 565
- interaction with mean flow, 577
- momentum myth, 568
- momentum transport, 566, 601
- of pressure and velocity in an elastic tube, 109
- of vorticity in an elastic tube, 148
- peaking 109, 114
- reflection 111
- refraction, 573, 577
- resistance, 568
- steepening 109, 116
- weldpool, 359
- western intensification, 512
- wind stress on the oceans, 510
- WKB asymptotic analysis, 197, 201, 204, 220
- Womersley, 106, 116
 - parameter, 118
- writhe, 385
- Young, 106
- Young's modulus, 111